EEU44C04 / CS4031 / CS7NS3 / EEP55C27
Next Generation Networks

5G

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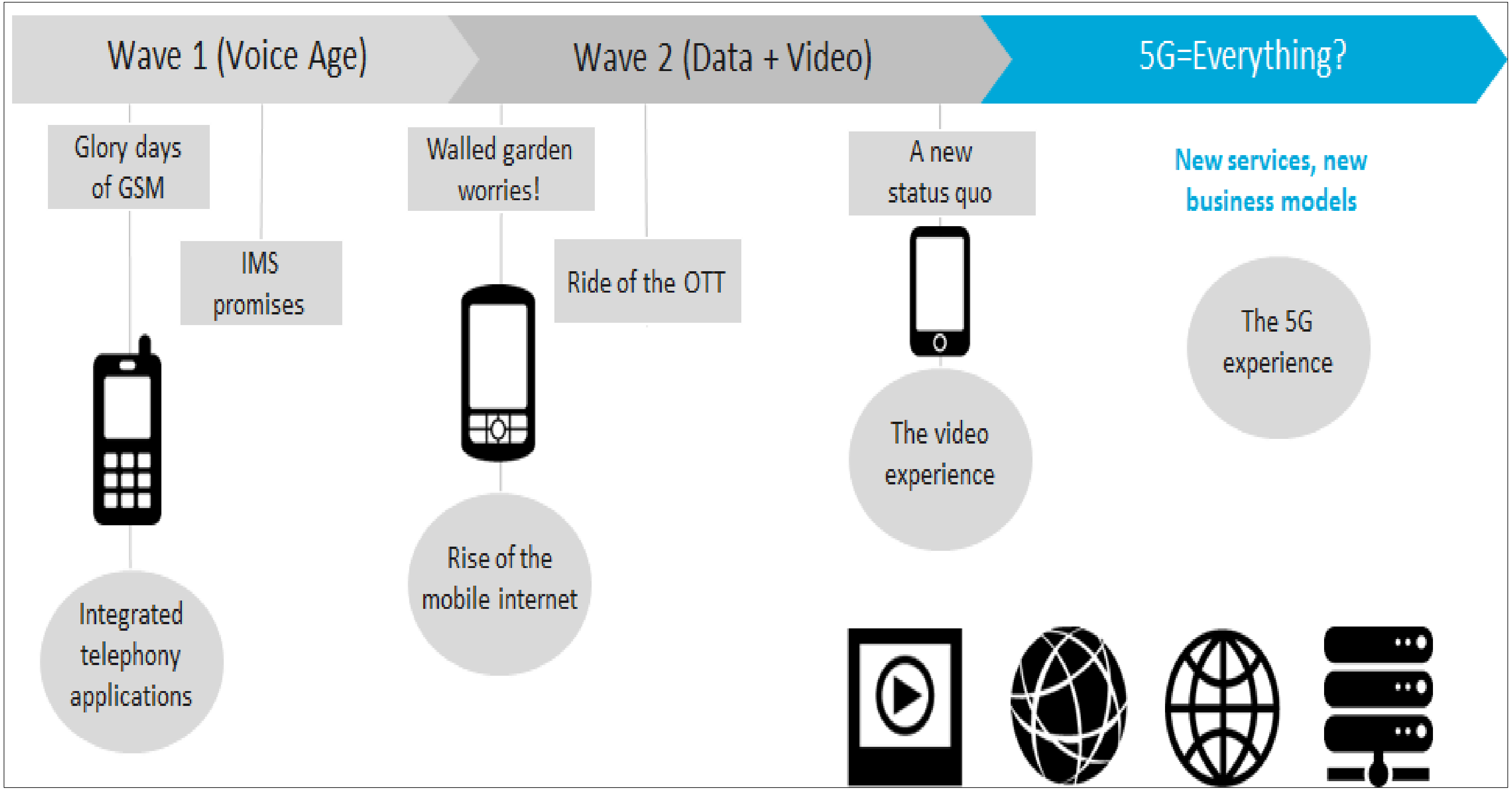
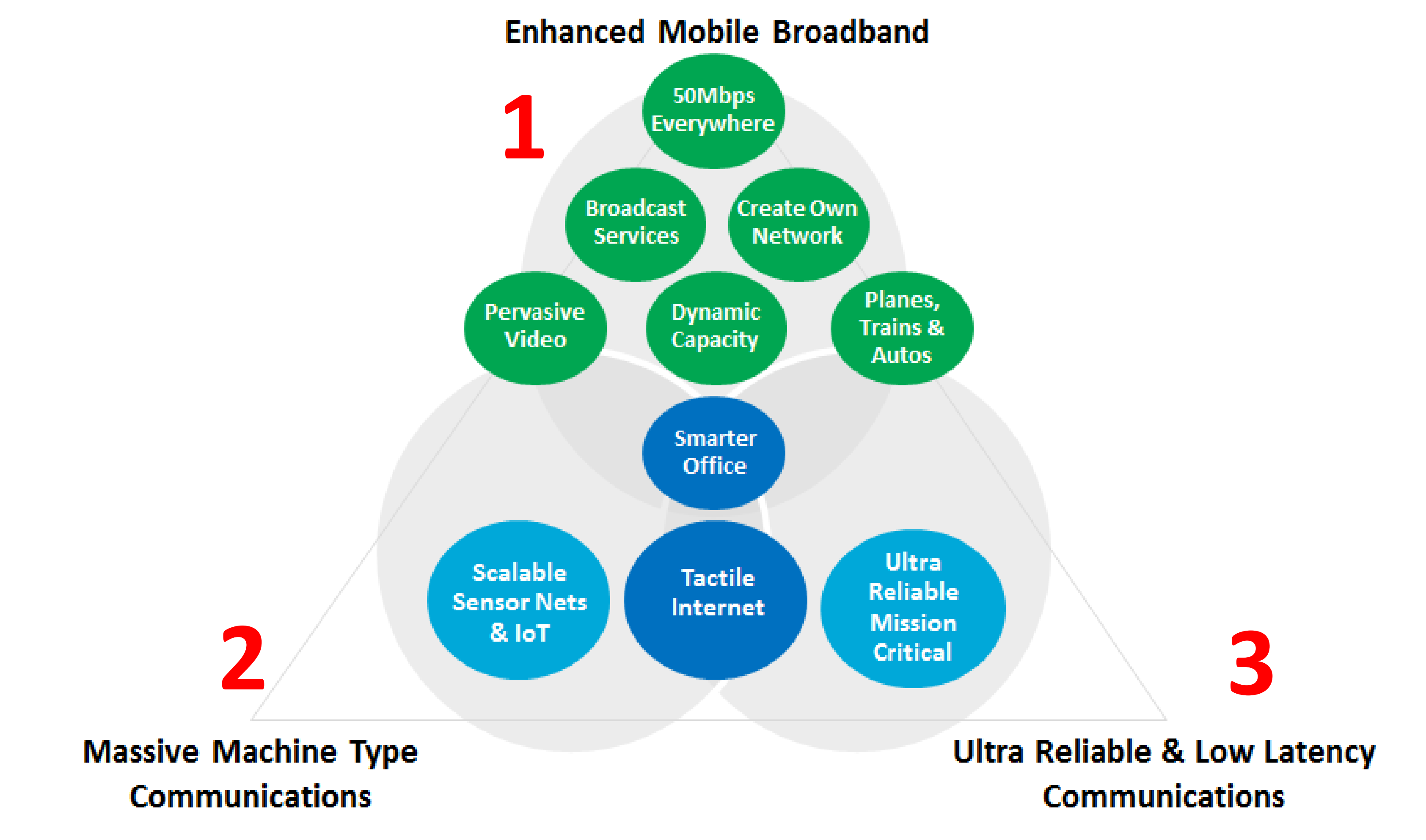
eMBB = enhanced Mobile Broad-Band
IoDT = InterOperability Device Testing
NR = New Radio

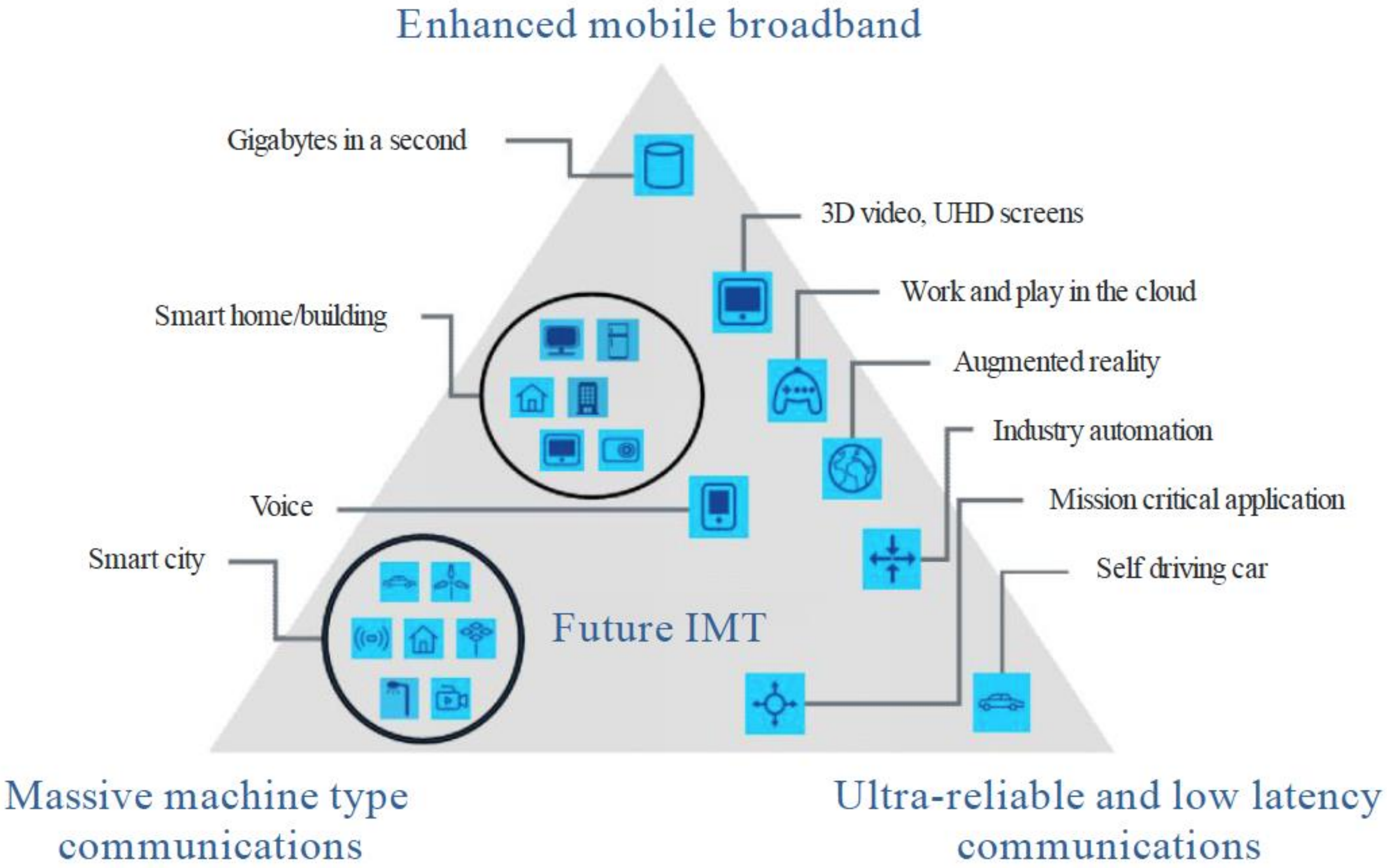
Release-15 and Release-16 Specification and Commercial launches timeline

3GPP 5G Roadmap (Release-15 and 16)

[Reference] Expanding the 5G NR ecosystem - 5G NR roadmap in 3GPP Release 16 and beyond, Qualcomm
https://www.qualcomm.com/media/documents/files/expanding-the-5g-nr-ecosystem-and-roadmap-in-3gpp-rel-16-beyond.pdf


Wave 1 (Voice Age)
Wave 2 (Data + Video)
5G=Everything?
Glory days of GSM
IMS promises
Walled garden worries!
Ride of the OTT
A new status quo
New services, new business models
Integrated telephony applications
Rise of the mobile internet
The video experience
The 5G experience


Enhanced Mobile Broadband
1
50Mbps Everywhere
Broadcast Services
Create Own Network
Pervasive Video
Dynamic Capacity
Planes, Trains & Autos
Smarter Office
Scalable Sensor Nets & IoT
Tactile Internet
Ultra Reliable Mission Critical
2
3
Massive Machine Type Communications
Ultra Reliable & Low Latency Communications


Enhanced mobile broadband
Gigabytes in a second
3D video, UHD screens
Work and play in the cloud
Smart home/building
Augmented reality
Industry automation
Voice
Mission critical application
Smart city
Self driving car
Future IMT
Massive machine type communications
Ultra-reliable and low latency communications

5G - Capabilities

- Truly pervasive video experience
- Revolution in the smart office
- 50Mbps everywhere
- Create your own network
- Support dynamic increase of capacity on the fly
- Working solution on planes, trains and cars
- Deliver a single scalable solution for sensor networks and the IoT
- Enable an ultra-reliable network for mission critical applications
- Make the realization of the tactile internet possible
- Deliver a meaningful and efficient broadcast service

5G: technical objectives

- **1,000 X** in mobile data volume per geographical area reaching a target of 0.75 Tb/s for a stadium.
- **1,000 X** in number of connected devices reaching a density ≥ 1M terminals/km^2.
- **100 X** in user data rate reaching a peak terminal data rate ≥ 1 Gb/s for cloud applications inside offices.
- **1/10 X** in energy consumption compared to 2010 while traffic is increasing dramatically at the same time.
- **1/5 X** in end-to-end latency reaching delays ≤ 5 ms.
- **1/5 X** in network management Operational Expenditure (OPEX).
- **1/1,000 X** in service deployment time reaching a complete deployment in **≤ 90 minutes**.
- Guaranteed user data rate **≥ 50 Mb/s**.
- Number of supported IoT terminals **≥ 1 trillion**.
- Service reliability **≥ 99.999%** for specific mission critical services.
- Mobility support at speed **≥ 500 km/h** for ground transportation.
- Accuracy of outdoor terminal location **≤ 1 m**.

KEY STEP CHANGES IN FUNCTIONALITY

IoE = Internet of Everything

4G purposed mainly for VIDEO… *IMT-2020* **5G** video ++ ● IoE ● TACTILE internet ● mission critical

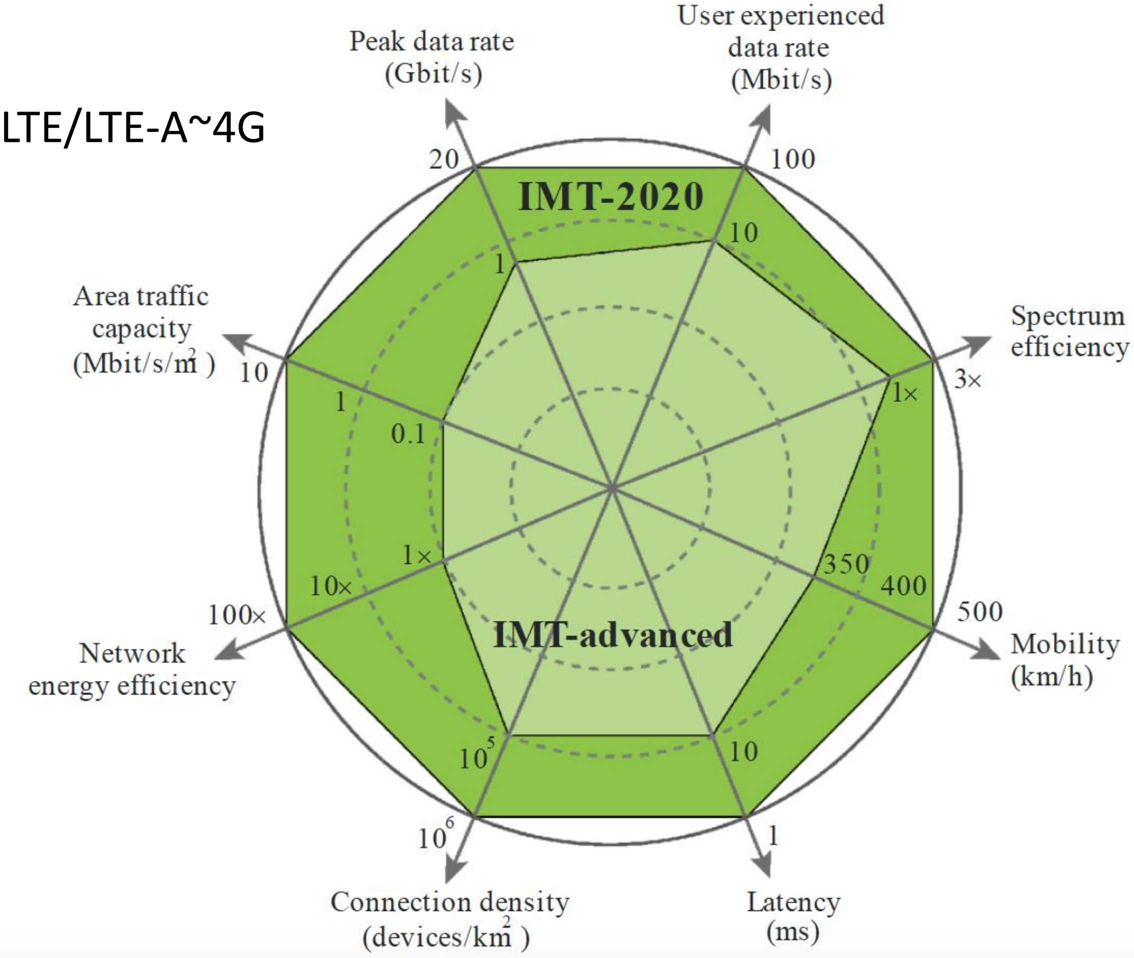
	LTE	LTE-A
Peak Data Rate:	50Mbps 150Mbps	500Mbps 1Gbps
Spectral Efficiency:	16.32 bps/Hz	30 bps/Hz
Carrier Bandwidth:	upto20MHz	upto100MHz
Latency (RTT):	~10ms	~5ms

<1millisecond latency (when needed)	**10-50Gbps peak data rates**	**90% Energy reduction per service**
100-500MHz Carrier Bandwidth	Higher Density: Millions of connections per km^2	Higher Traffic Volume: 1-10 Tbps per km^2
Rapid Service Creation (from days to minutes)	Sustainable Total Cost of Owner for all players	User Definable Security & Privacy

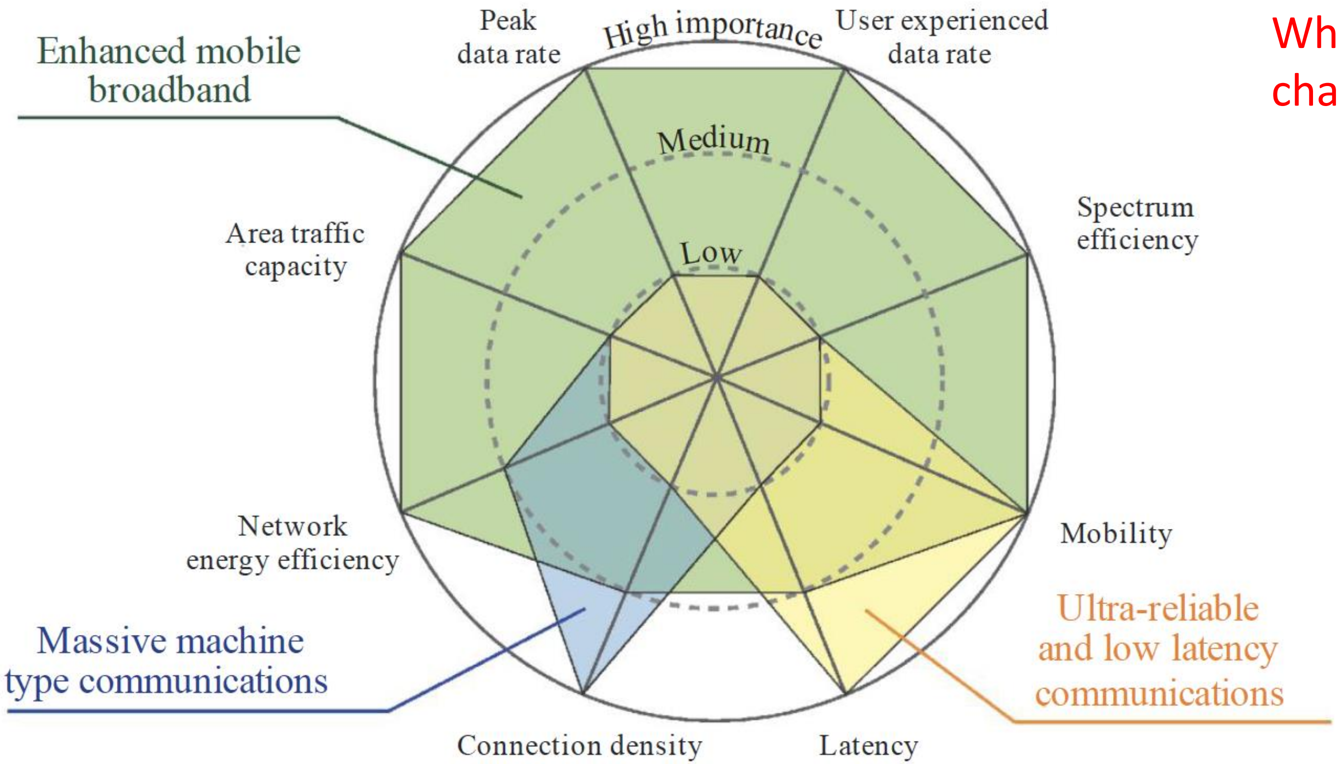
*Key requirements harmonized & agreed in ITU-R WP5D

IMT-Advanced ~ LTE/LTE-A~4G

IMT-2020 ~ 5G



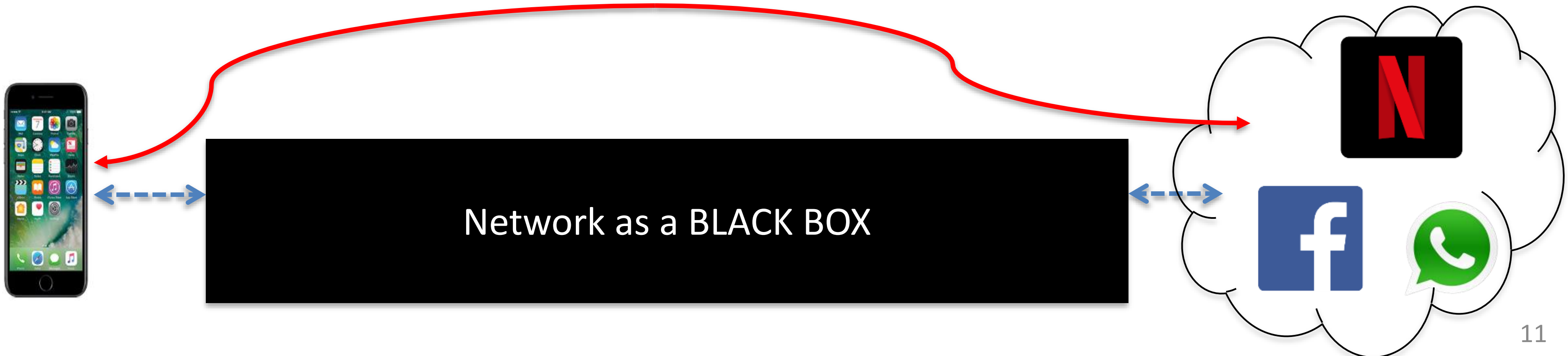
How the ITU see 5G v 4G



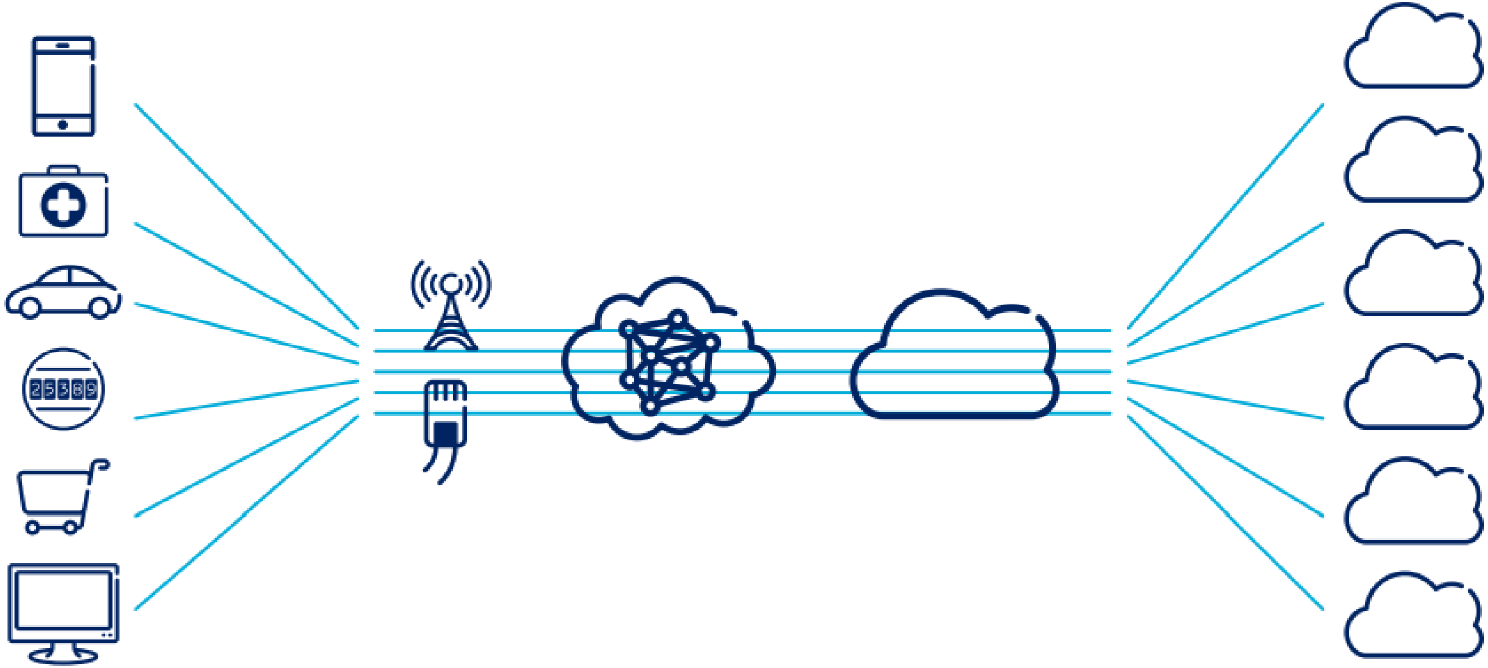
What's the challenge here?

OTT v 5G

- Previously (or to date) most innovation has occurred over-the-top of the network
- Apple, Android platforms enable developers to create apps that use the network as a dumb/passive bit pipe
- No network customisation for apps or services



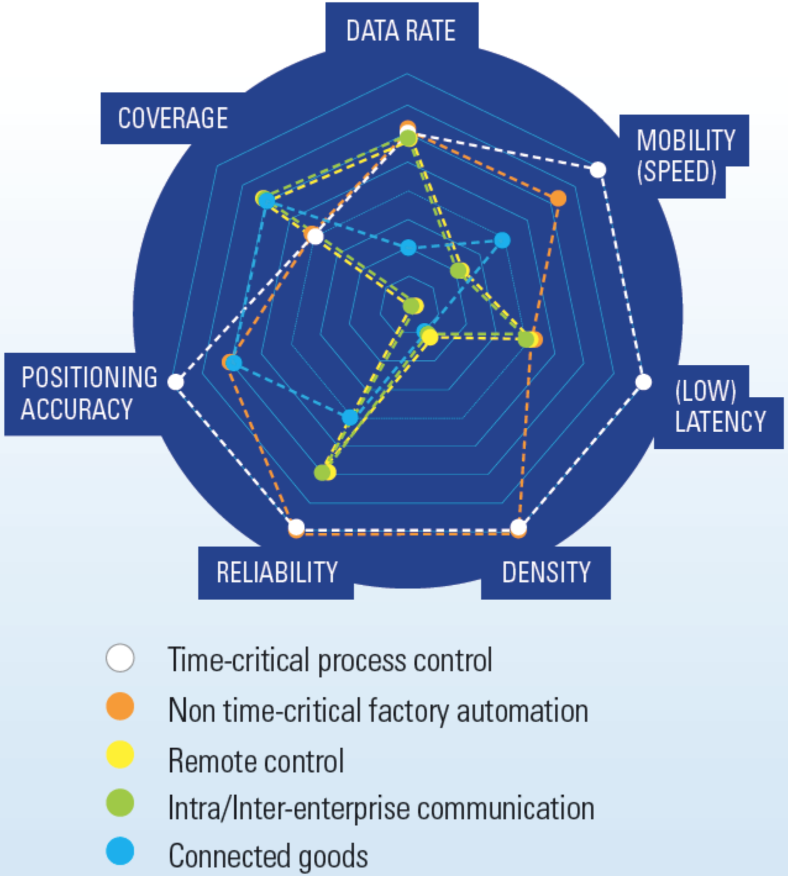
5G. VG. V for Verticals



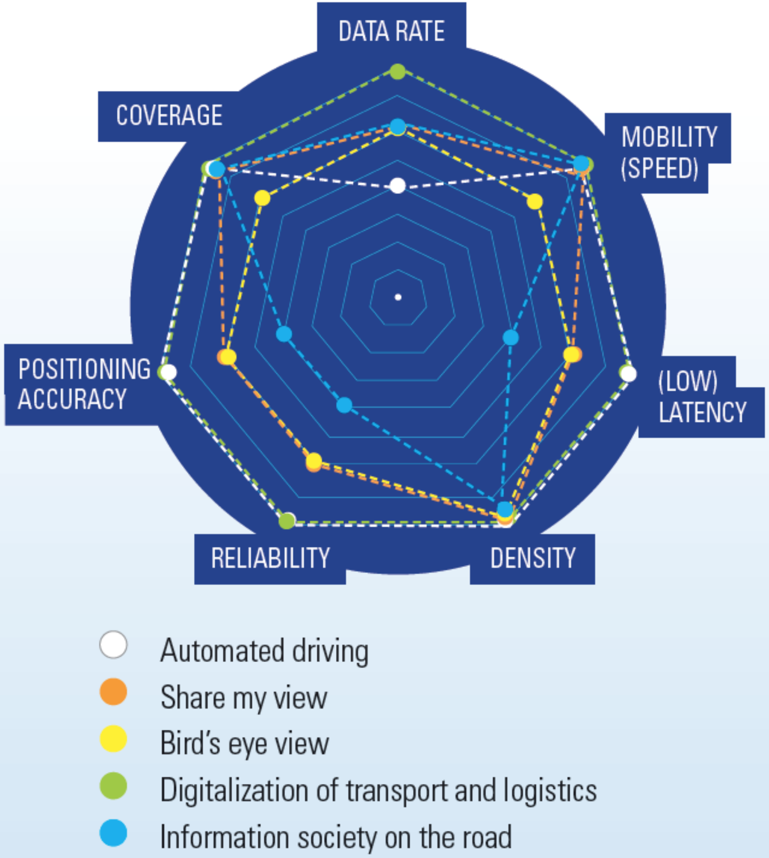
- Moving from one-size-fits-all dumb bit pipe to tailored network services.

Paper	Vertical details
4G Americas	Automotive, health, public safety
Ericsson 5G	Automotive, health, government, utilities, manufacturing and transport
GSMA	Automotive, augmented reality, tactile internet, virtual reality
Intel	Specific verticals not mentioned
ITU	Specific verticals not mentioned
Metis	Activities: virtual reality office, smart grid, emergency communications, IoT, traffic efficiency and latency
NGMN	Automotive, health, energy and home
Samsung	Connected car, fitness and healthcare
Qualcomm	Autonomous vehicles, healthcare and emergency response

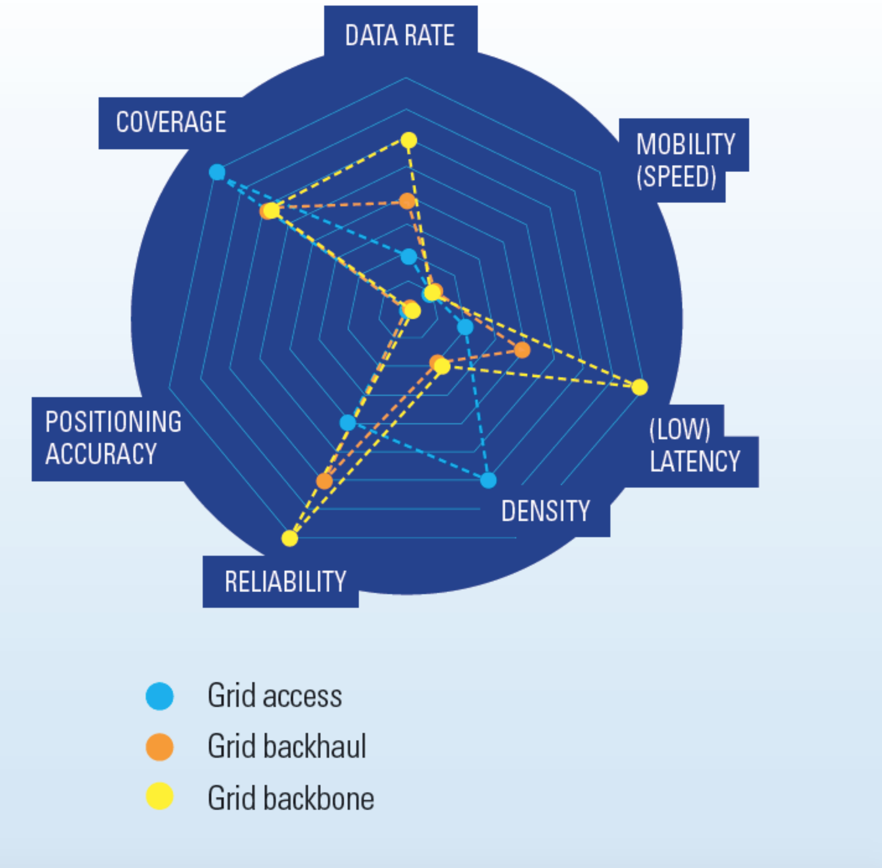
FACTORIES


DATA RATE
MOBILITY (SPEED)
(LOW) LATENCY
DENSITY
RELIABILITY
POSITIONING ACCURACY
COVERAGE
Time-critical process control
Non time-critical factory automation
Remote control
Intra/Inter-enterprise communication
Connected goods

AUTOMOTIVE


DATA RATE
MOBILITY (SPEED)
(LOW) LATENCY
DENSITY
RELIABILITY
POSITIONING ACCURACY
COVERAGE
Automated driving
Share my view
Bird's eye view
Digitalization of transport and logistics
Information society on the road

ENERGY


DATA RATE
MOBILITY (SPEED)
(LOW) LATENCY
DENSITY
RELIABILITY
POSITIONING ACCURACY
COVERAGE
Grid access
Grid backhaul
Grid backbone

One-size-doesn't fit all

- Traditional, one-size-fits-all network architectures with purpose-built systems worked well for **single-service subscriber networks** with **predictable** traffic and market growth
- However, the resulting vertical architecture has made it difficult to scale telecom networks, adapt to changing subscriber demands and meet the requirements of emerging use cases
- Cloud technologies together with Software-Defined Networking (SDN) and Network Functions Virtualization (NFV) provide the tools that enable architects to build systems with a **greater degree of abstraction** – which enhances network flexibility
- **Cloud, SDN and NFV technologies allow vertical systems to be broken apart into building blocks, resulting in a horizontal network architecture that can be chained together** – both programmatically and virtually – **to suit the services being offered and scaled**

Network slicing

aaS = as a Service

- Take a network and build it so flexibly that it can be:
  - Shared by multiple different user-types
  - Architecture is tailored to use-type needs
  - Resources allocated in a granular fashion
  - Billed in a granular fashion

- **5G-as-a-Service** ← XaaS - very influenced by cloud thinking

Network Slices

- A **network slice** is a connectivity service defined by a number of *customizable software-defined functions* that govern geographical coverage area, duration, capacity, speed, latency, robustness, security and availability

- The concept of network slices is not a new one; a VPN, for example, is a basic version of a network slice. But the wide range of use cases and tougher requirements that future networks will need to support, suggests that network slices in the context of 5G need to be defined on a whole new level, more like **networks on-demand**

SDN – Software Defined Networks

- The benefit of SDN lies in its ability to provide an **abstraction of the physical network infrastructure**. Through *network-wide programmability* – the capability to change the behavior of the network as a whole – SDN greatly simplifies the management of networks

- The level of network programmability provided by **SDN allows several network slices - customized and optimized for different service deployments - to be configured using the same physical and logical network infrastructure**. One physical network can therefore support a wide range of services and deliver these services in an optimal way

NFV– Network Function Virtualisation

- By *separating hardware from software*, **NFV allows a network function to be implemented programmatically instead of by a physical piece of hardware.** This capability enables *instant scalability*, which supports the delivery of services like capacity or coverage on demand

- The most significant benefit brought about by NFV is the **flexibility to execute network functions independently of location**. By virtualizing a network function, it is no longer bound to a specific location or node. The same network function can be executed in different places for different network slices. *Depending on the use case*, a network function could either be placed in a centralized data center (DC) or close to a base station (BS). By placing network functions accordingly, the same physical infrastructure can provide connectivity with *different latencies*

Softwarization of networks is a key trend.

Network slicing

Service Level Agreements (SLA)
→ big feature of 5G

The benefit of slicing networks is not just the **capability to deliver a wide range of connectivity services to any industry, but also to ensure that usage can be billed accordingly**. Slicing networks provides greater insight into network resource utilization, as each slice is customized to match the *level of delivery complexity* required by the service or services using the slice.

SMART METER SERVICE

- A utilities company, for example, requires connectivity for its **smart meters**.
  - This need could be translated into a network slice that connects a number of machine-to-machine (M2M) devices with a latency and data rate that enable upload of periodic status updates within a given time. The **security** level of the service is medium, and it is a **data-only** service that requires **high availability and high reliability**.
  - *Additional network functions associated with higher levels of security, longer durations or increased reliability could be configured* to suit the needs of the application.

Network slicing

Service Level Agreements (SLA) → big feature of 5G

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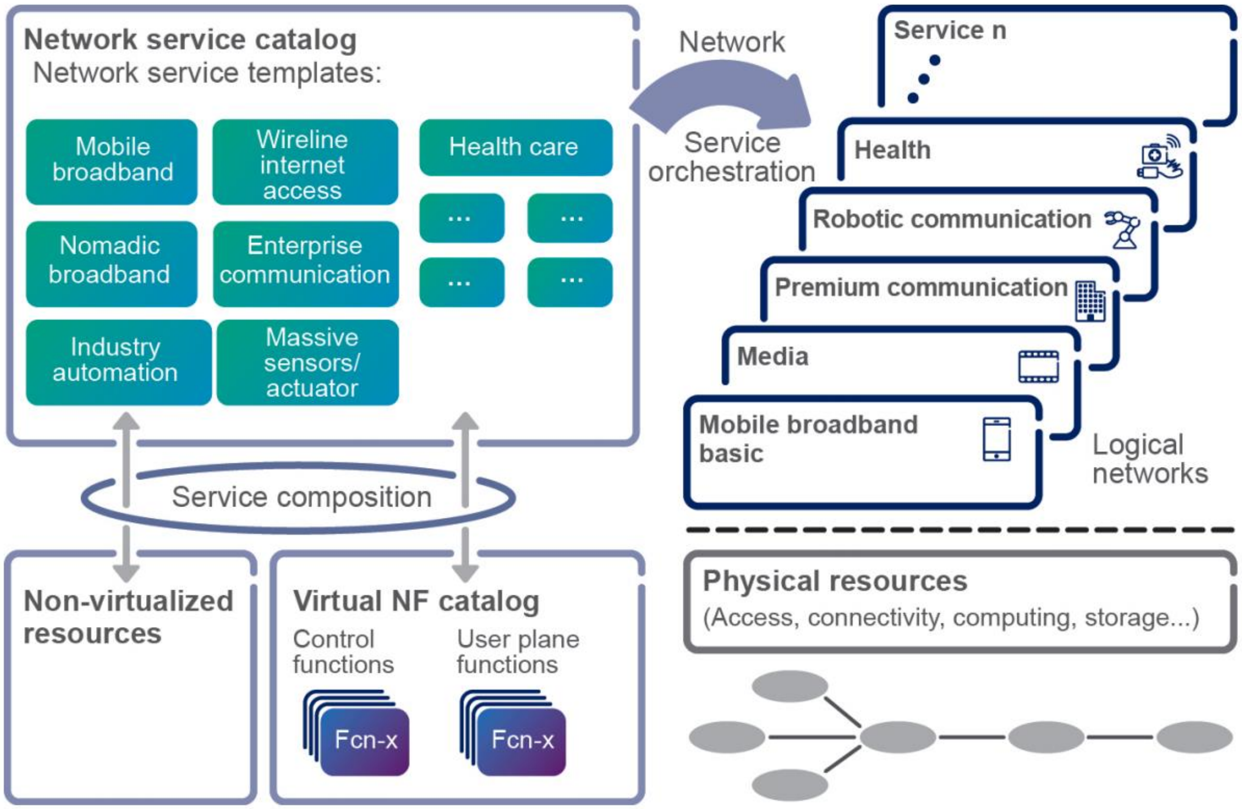
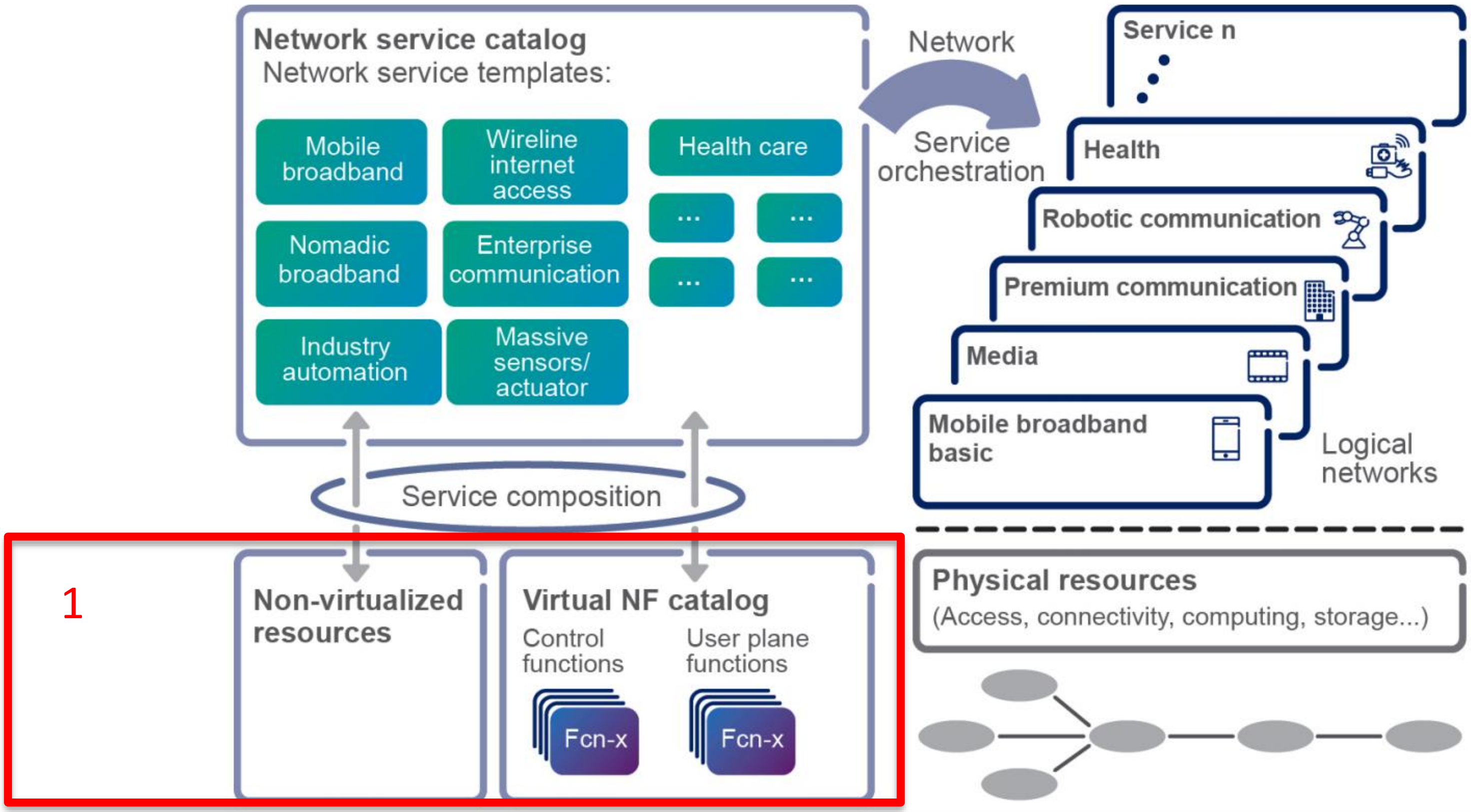
SENSOR UTILITY SERVICE

- The same utilities company as before may require connectivity for its **fault sensors**. The network slice for this type of service needs to be able to receive round-the-clock status indicators or alarms from all the M2M devices in the system. This use case requires data-only coverage with high availability and robustness, and medium security and **latency**.
- Again, depending on the use case, a network slice delivering this connectivity service can be configured with different network functions to enable **higher levels of security**, or **near-zero latency**, for example.

5G is (or will be??) a programmable, dynamic network



5G is (or will be??) a programmable, dynamic network



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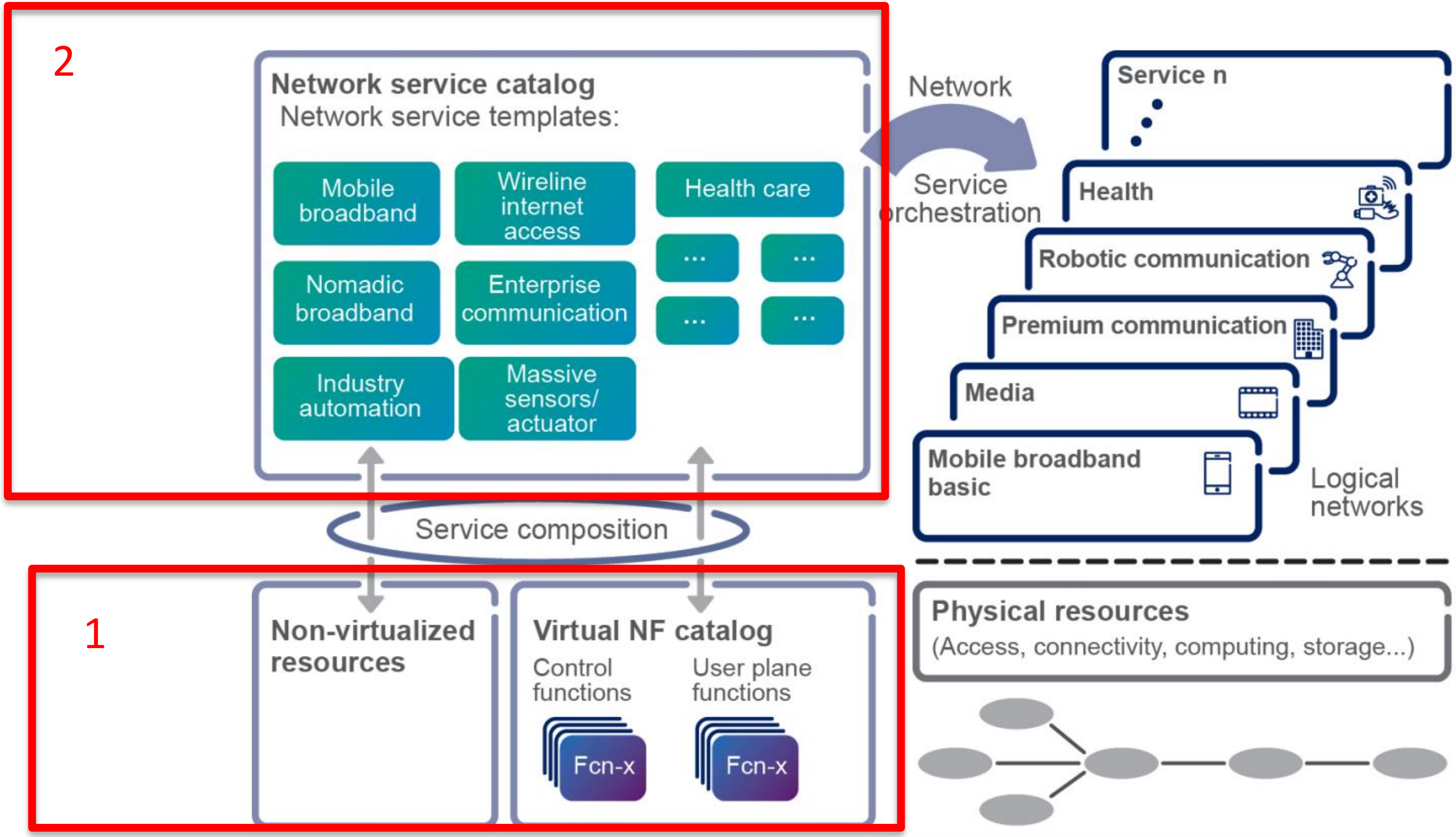

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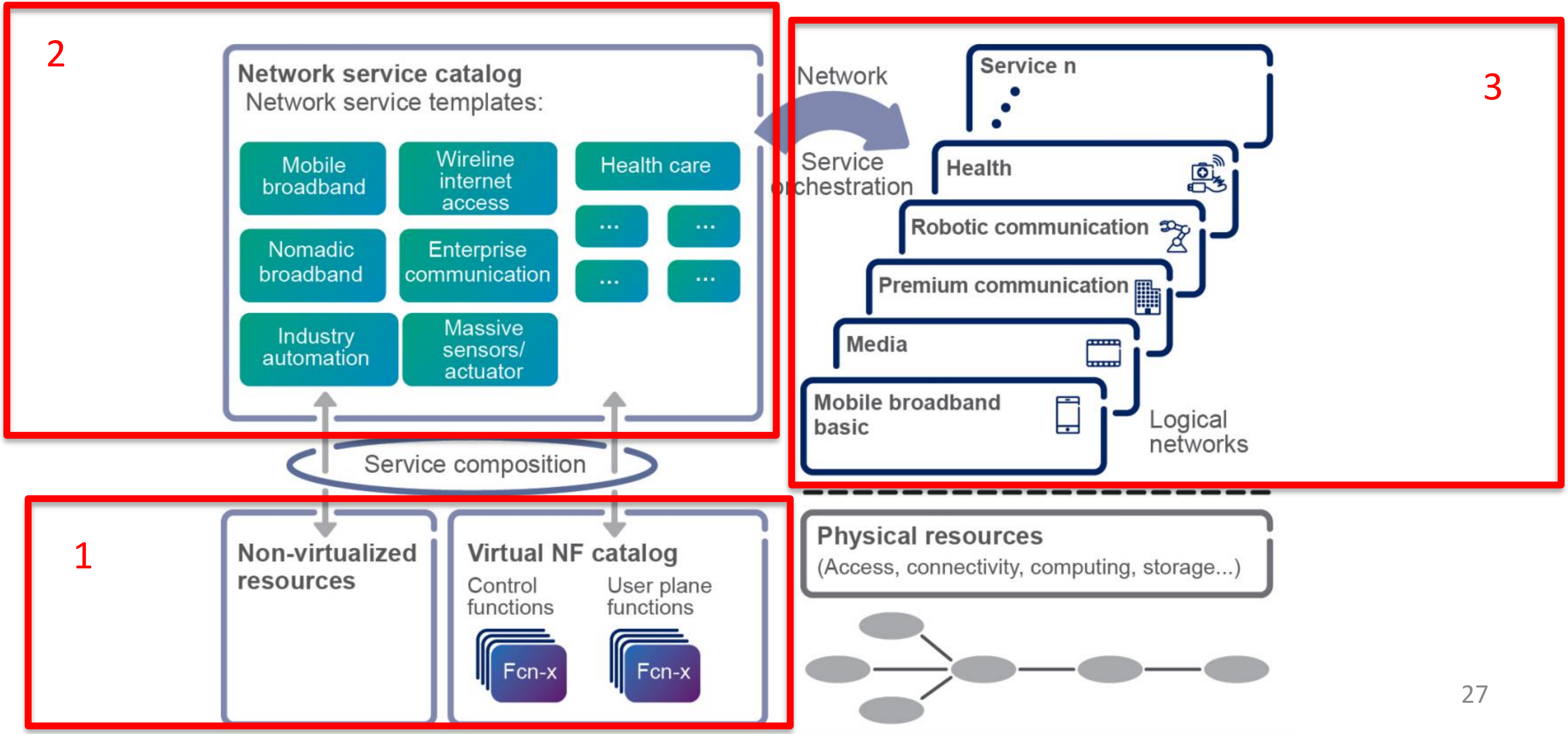
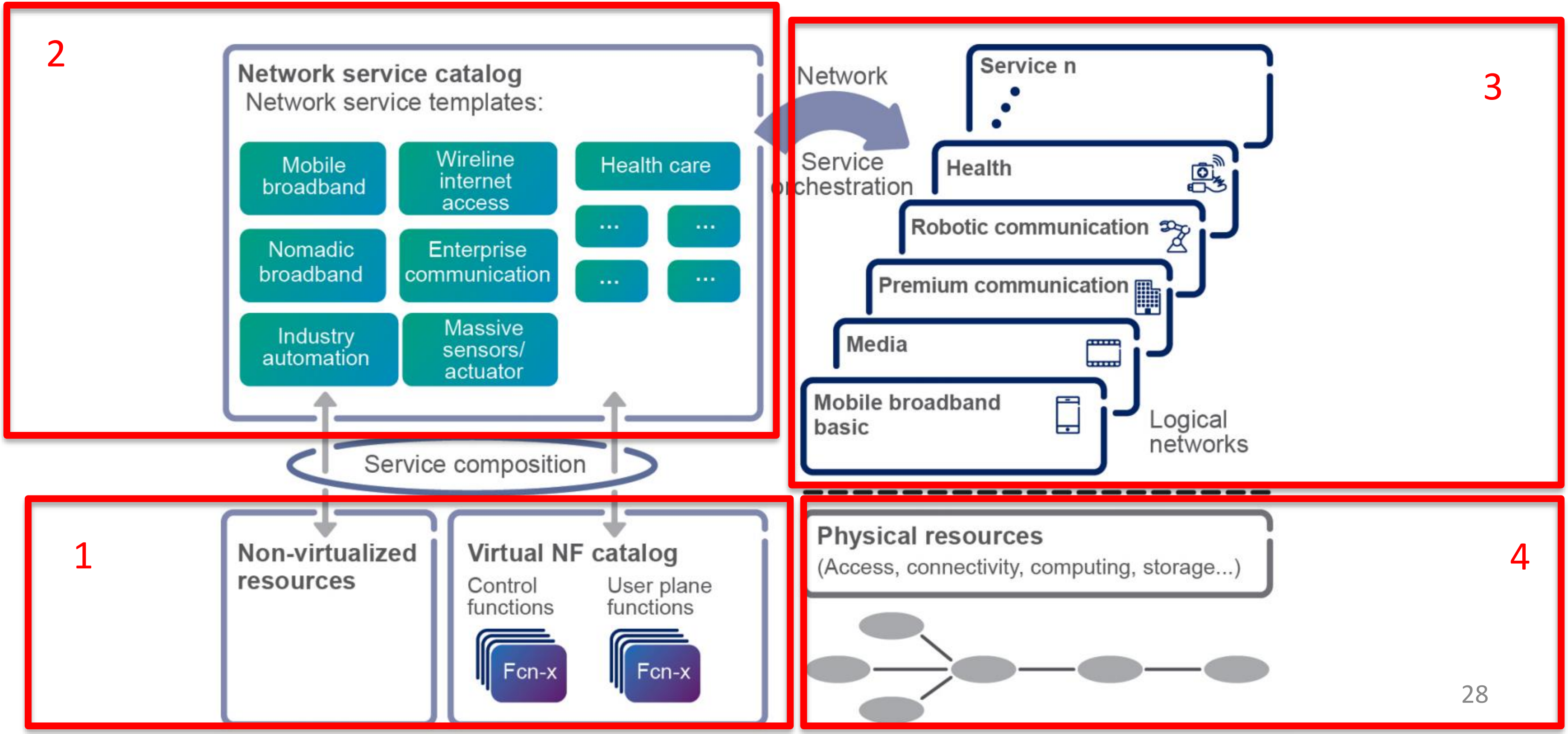


5G is (or will be??) a programmable, dynamic network



Which one among the following requirements is most important for the massive machine type communication systems?

- ❑ Very high throughput per connection
- ❑ Very low latency
- ❑ Very high connection density

Which one among the following requirements is most important for the massive machine type communication systems?

- ❑ Very high throughput per connection
- ❑ Very low latency
- ❑ **<u>Very high connection density</u>**